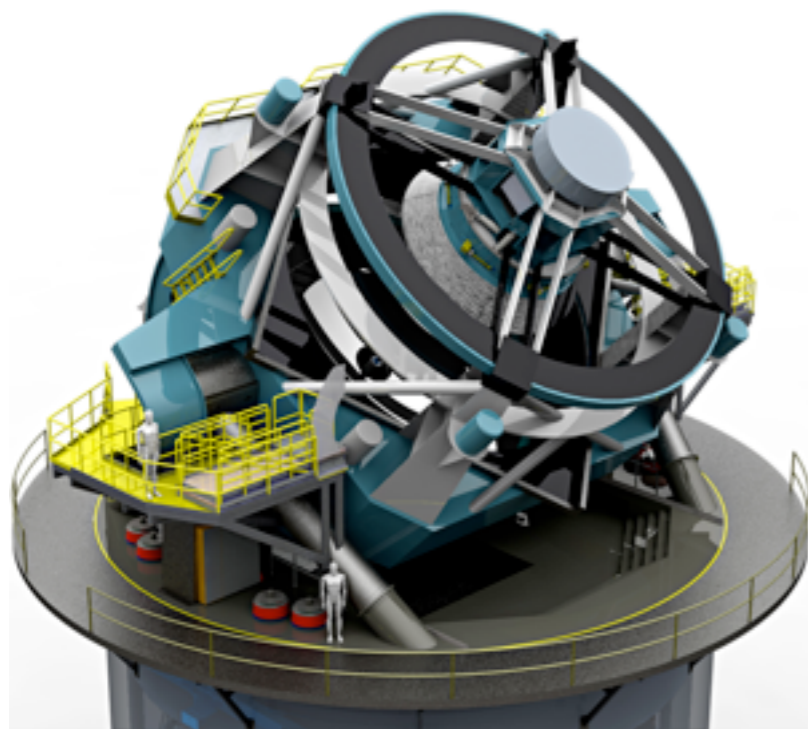


LSST@Argonne

Amazing Mirrors and Superlative
Supercomputers

*Argonne's Mira will accelerate scientific discoveries
and societal benefits.*

November 29, 2011



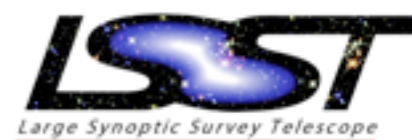
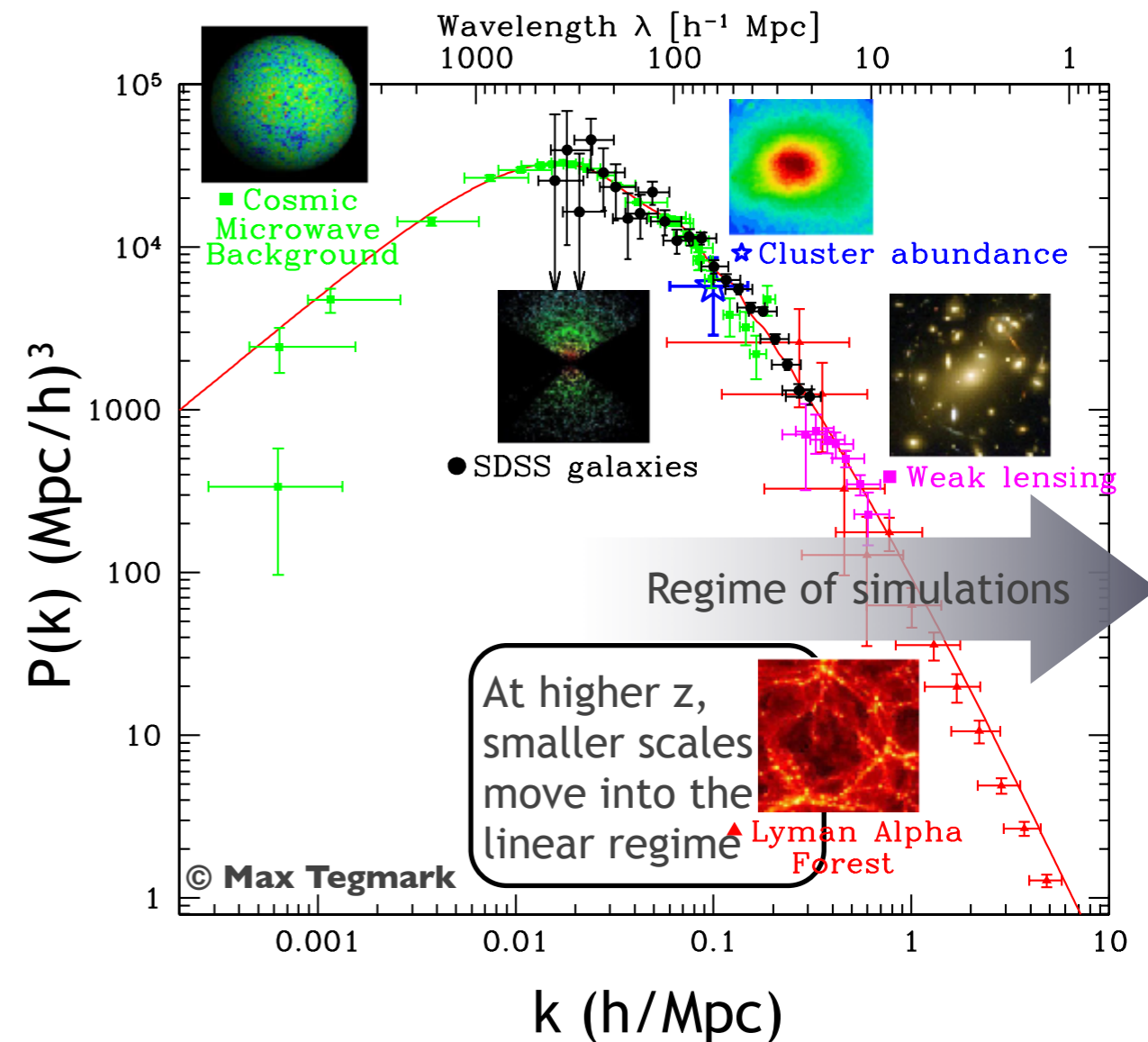
**Mira, 10 PFlops,
installation in progress**

Experiment/Observation -- Theory/Computing/Analysis

Salman Habib
High Energy Physics Division
Mathematics & Computer Science Division
Argonne National Laboratory

Dark Universe Probes and LSST

- CMB probes large scales and early times, anchors paradigm (>10 Mpc)
- ✓ Sn distance measurements ($0 < z \sim 2$)
- Ly α : Neutral hydrogen distribution seen as absorption features in spectra of distant objects (1-10 Mpc, $2 < z < 3$)
- ✓ Lensing: Light deflection by density inhomogeneities ($> \sim 1$ Mpc, $0 < z \sim 1$)
- ✓ Galaxies are biased tracers of the density field (> 1 Mpc, $0 < z \sim 2$)
- ✓ Object abundance probes tails of density distribution, clusters most sensitive (~ 10 Mpc, $0 < z \sim 2$)



LSST: The Project and LSST DESC

Progress in becoming LSST institutional members --

Need to send Letter to LSST Corp. (Tony Tyson has already ok'd draft plan)

Possible contributions to the LSST project (Camera)

- (i) Discussions with Steve Kahn regarding ANL options
- (ii) Steve attended LSST camera workshop with Gary Drake (lead electronics engineer), useful discussions with LSST electronics groups
- (iii) Steve: Discussions with LSST calibration group members (Depoy, Allyn Smith), also collaborators on PreCam
- (iv) Discussions on best way to ramp up learning curve in all areas to be ready when project 'holes' emerge

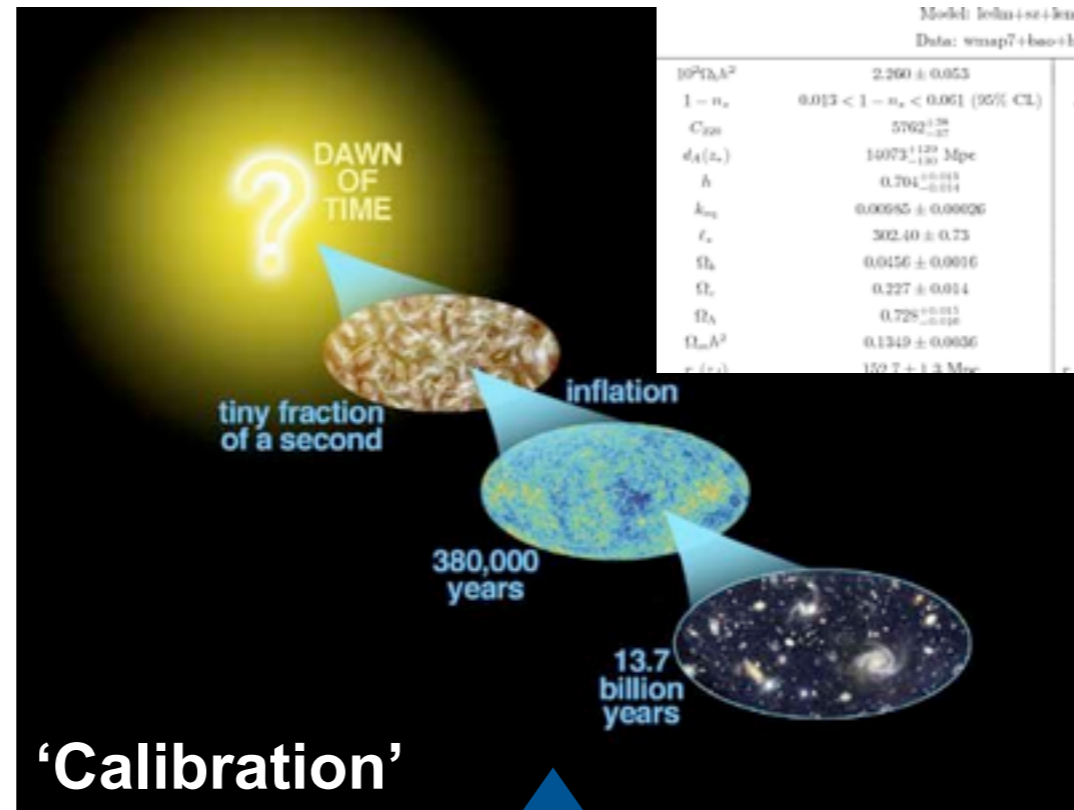
Key ANL contributions to the LSST Dark Energy Science Collaboration

- (i) Simulation/Prediction tools for science projects, control of systematic errors and degeneracies in combined analyses, next-generation emulators, covariances, mock catalogs, -- (ANL CFT group + collabs)
- (ii) Simulation/Analysis interface; simulation/analysis server (data-intensive computing pilot project approved at NERSC) (ANL CFT group + collabs)
- (iii) Supernova systematics, sub-type correlations, anisotropy, -- (ANL work led by Steve)

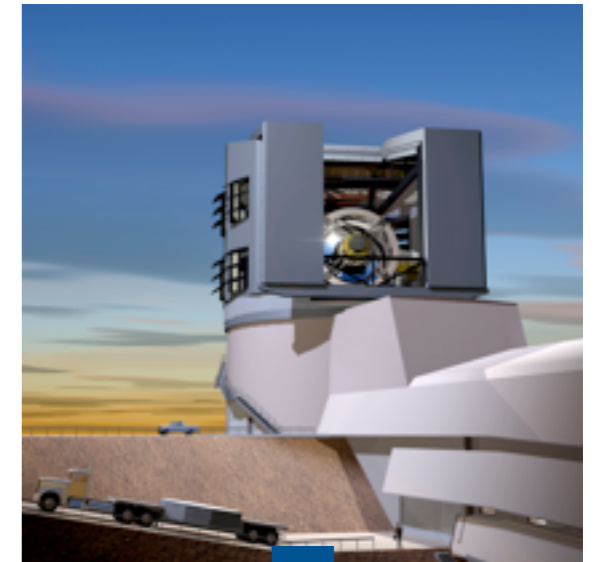


Precision Cosmology: Calibrating the Universe with LSST

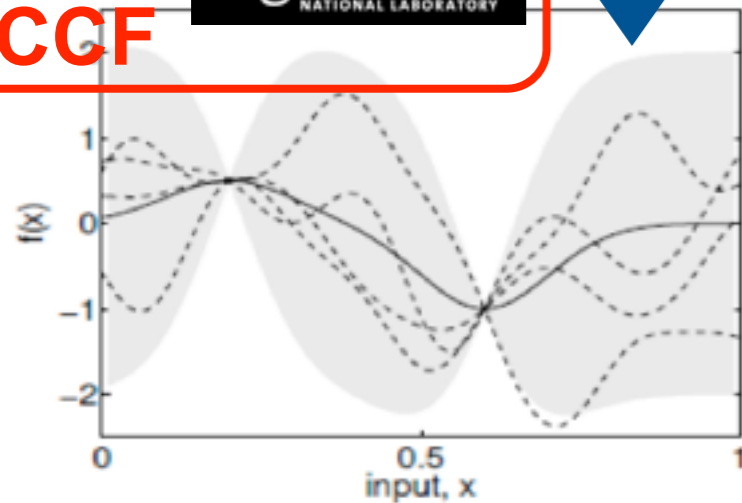
Supercomputer Simulation Campaign



Mapping the Sky with Survey Instruments

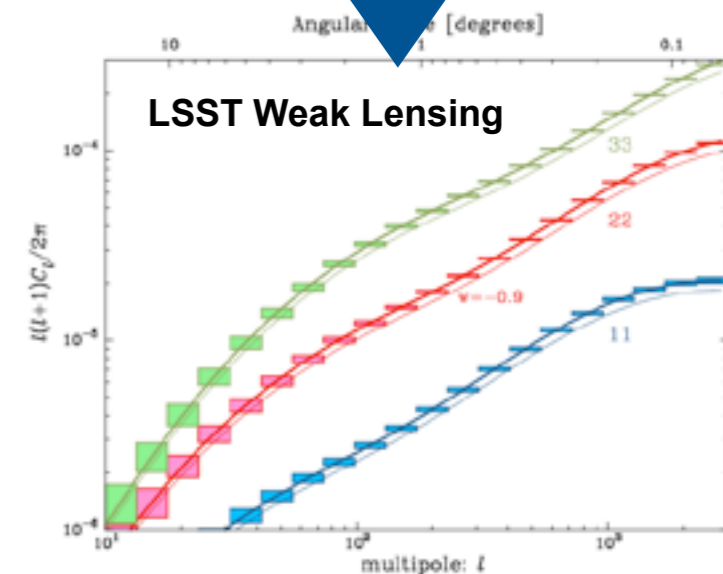
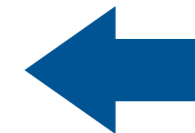
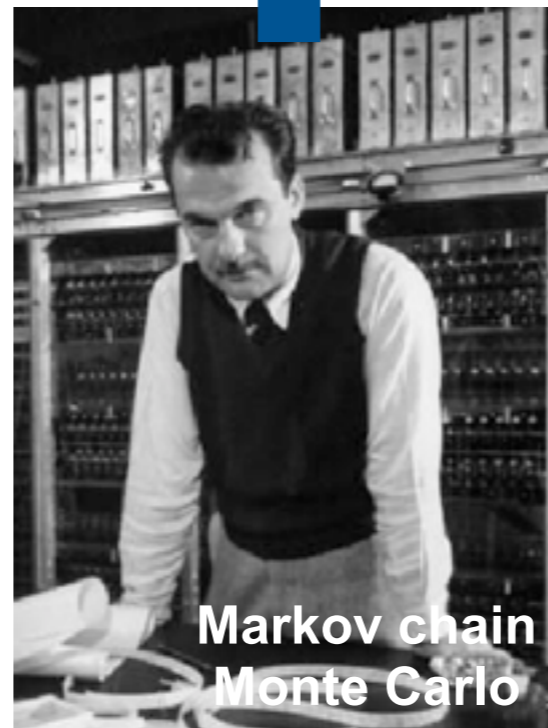


**HACC
+
CCF**



**Emulator based on GP
Model Interpolation in
High-Dimensional
Spaces**

**'Precision
Oracle'**



**Observations:
Statistical error bars
will 'disappear' soon!**

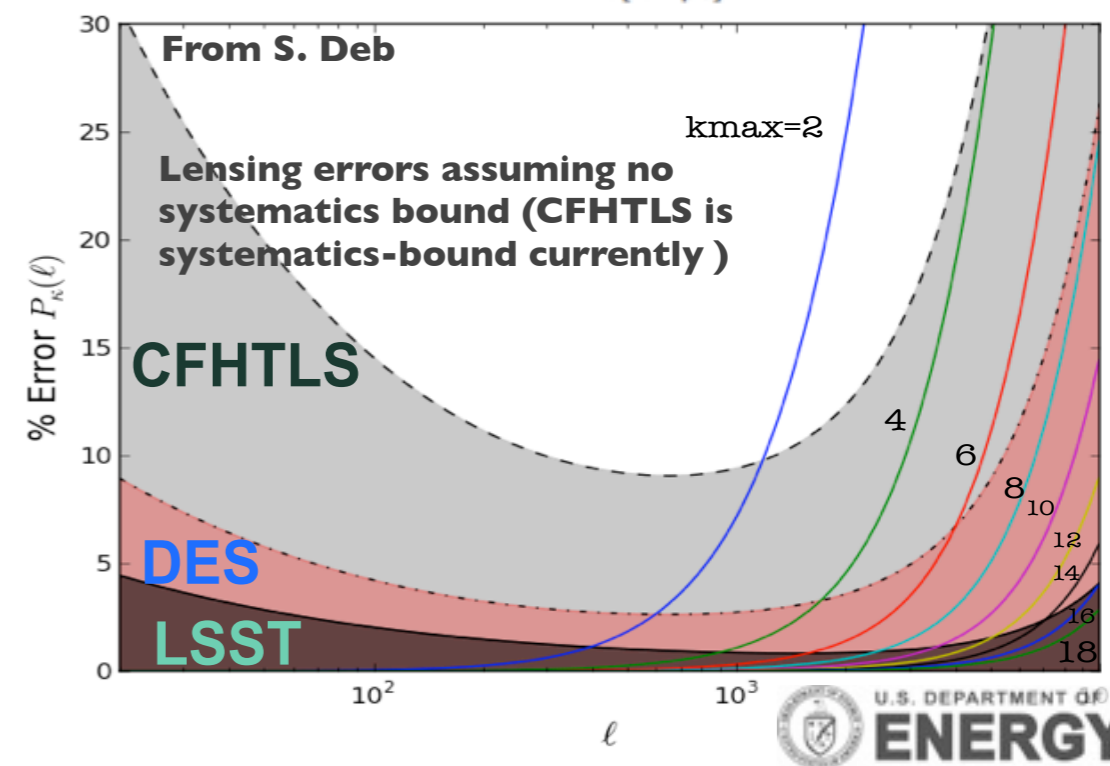
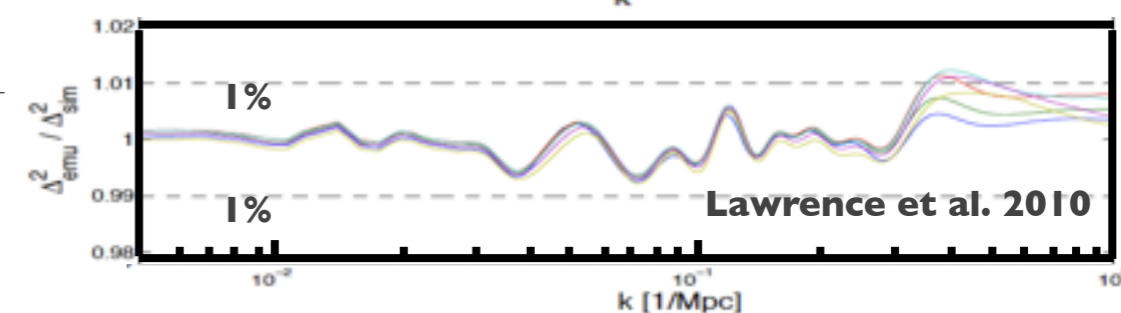
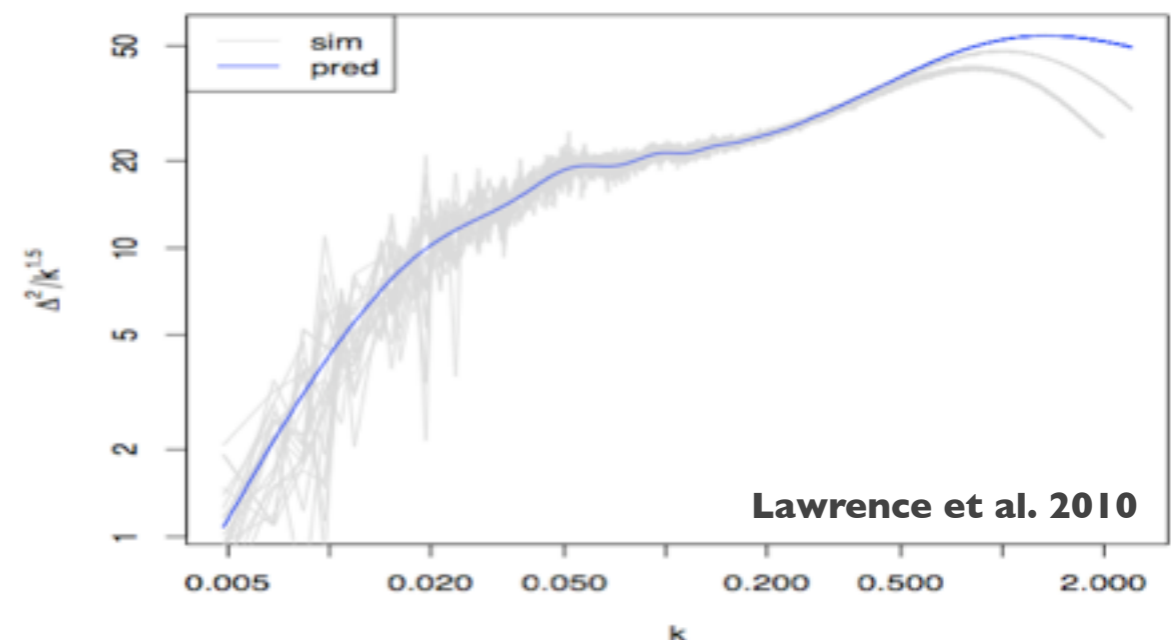


LSST Probes: 'Wide-Area' Simulation Challenges

- **Photometric Baryon Acoustic Oscillations (BAO)**
 - **Measurement:** Geometry at $z < 1$
 - **Challenge:** Large volume N-body simulations to precisely determine BAO 'wiggles' in $P(k)$ or peak in the correlation function, effect of photo-z's
 - **Cluster counts**
 - **Measurement:** Geometry and structure growth
 - **Challenge:** Large volume N-body (plus N-body/hydro to help characterize observable-mass relations)
 - **Redshift-space distortions with photo-z's**
 - **Measurement:** Growth of structure, tests of modified gravity
 - **Challenge:** Large volume N-body simulations to determine and characterize/model galaxy velocities, model photo-z based observations
- **Weak lensing (Key for LSST)**
 - **Measurement:** Multiple uses -- geometry, growth, cluster mass
 - **Challenge:** Large volume N-body (plus N-body/hydro simulations to evaluate baryonic systematics, intrinsic alignments, --)

WL: Removing Theory Systematics for DES/LSST

- **Accuracy requirement:** $P(k)$ calibration needed at $<1\%$ level to $k \sim 10$ h/Mpc over a broad range of cosmologies
 - **Emulation:** ‘Coyote Universe’ suite of ~ 1000 simulations used to build predictors in the gravity-only case to $\sim 1\%$ absolute accuracy extending out to $k \sim 1$ h/Mpc; (now extended to $k \sim 10$ h/Mpc; $4 > z > 0$ for DES)
- **Baryonic Effects:** Starting at scales of $k \sim 1$ h/Mpc, baryonic effects become important posing a significant computational modeling challenge (initiated addition of modeling component to N-body simulations), working on DES & LSST issues



LSST Mock Catalogs

Next-generation mock catalogs for LSST based on very large, high-resolution simulations at ANL --

collaboration with M. White (Berkeley/LBNL), A.J. Connolly (UWashington), A. Benson (Caltech), D. Silver (Rutgers) and ANL HEP/MCS team

Simulation sizes and analysis tools

- (i) Will combine 100's of billions to multi-trillion particle simulations with HACC on Mira + halo tracking/merger tree analysis suite + Galacticus semi-analytic modeling code
- (ii) Resulting mocks will be compared to and tuned against current observations
- (iii) Mocks will be used for a host of LSST science/systematics tests and for exercising the LSST data and analysis pipelines
- (iv) Discussions on best way to ramp up learning curve in all areas to be ready when project 'holes' emerge

Simulation/Analysis server

- (i) New NERSC data-intensive pilot award will enable us to set up a portal for LSST DESC collaboration to interact with simulation results and carry out remote analyses

